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RESEARCH MANAGEMENT

BACKGROUND PAPER
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INTRODUCTION

The management of agricultural and related research is of greater than passing interest to all of us in the Agriculture, Food and Nutrition Sciences Division. All of our effective working contacts are with research managers, whether they be the leaders of small forestry projects or the Directors General of IARCs.* We could ourselves be described as research managers, in that we provide money, technical support and guidance to research activities which we have judged to be worthy of IDRC support. We are invested with the most powerful management decision: the ability to restrict or curtail financial supply when it appears necessary to do so. Nonetheless, it is my belief that with few exceptions, during the past five years of the Division's existence, we have concerned ourselves more with the techniques of research than with the broader issues of research management. It is incumbent upon us to improve our capability to manage more effectively the IDRC resources for which we are responsible and perhaps more important, to help scientists in developing countries and those in the IARCs towards a more comprehensive understanding of research management.

According to Boyce and Evanson (Agricultural Research and Extension Program), investment in agricultural research throughout the world has increased five-fold in 20 years from about $750 million in 1951 to more than $3,800 million in 1974. In spite of this very sizeable investment in agricultural research, there

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has been no comparable investment in the study of the training of people for agricultural research management. There appears to be an implicit belief that those who can do research can manage research. This may be true in universities where the focus centers upon teaching research techniques and research philosophy, however, I believe it is demonstrably untrue in enterprises dedicated to applied research for human benefit.

WHAT IS MANAGEMENT?

The word "Management" derives from "manus", the Latin word for hand and it originally referred almost exclusively to the handling and training of horses.

Shakespeare in Henry V writes: "Speak terms of manage to thy bounding steed", and Sir Thomas Hoby in his 16th Century translation of "Il Cortegiano de Castiglione" writes: "It is peculiar praise of Italians to manage particularly rough horses".

Management appears to have been interpreted by many of its practitioners to mean something similar to other words derived from the same root, such as "manipulate" and "mancipate", the latter being the state in which slaves exist. Some confusion exists between management and administration, the latter being derived from "ministere" meaning "to serve". In industrial circles, administration is regarded as only one component of management. Governments however assign a higher hierarchical importance to ministers and administrators, as the senior representatives of the civil service, though with the increasing dominance of government in our daily affairs, the term "service" is tending to lose its original meaning.

Sir John Lydgate, the 15th Century poet, stated that government administrators should be: "Such as are of greatest bounty", "bounty" meaning "full of goodness". Since the concept is gaining acceptance that management is not a mechanistic

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technique but is essentially concerned with guiding human effort and serving human needs, Lydgate appears to have been somewhat ahead of his time.

Peter Drucker, the American high priest of management and his many disciples have produced an impressive body of literature under the general heading "scientific management" or "management science". Drucker's convincing arguments notwithstanding, I cannot accept that management is a true science in that it cannot be described as a connected body of demonstrable scientific truths based upon repeatable experimental results. Much of the literature appears rhetorical and much of its standard vocabulary capable of widely different interpretation.

Most of the "management" literature is written for and most schools of management are financed by private industry. Consequently, management studies tend to be oriented towards material gain rather than human need, since the end-purpose of industrial management is greater profits for the shareholders.

Even among many government and international research institutions the satisfaction of a human need appears as of lower visible priority than scientific and technical objectives. In several Canadian government departments the main criterion of satisfactory research appears to be the number of papers published in refereed journals.

IDRC's concern is with the management of research for the benefit of the underprivileged. Consequently, our standards should be different from those of industrial enterprises. Nevertheless, all of the considerable investment in industrial research management is by no means irrelevant and a thoughtful study of the literature on industrial management will suggest what from the collective experience can be adopted, what might be adapted, and what should be rejected.

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HISTORY OF MODERN MANAGEMENT

The basis of the philosophy and practice of modern industrial management is to be found in the industrial revolution of the late 17th and early 18th Century. The apparatus of medieval industry was very simple. It consisted of craftsmen, each of whom owned his own tools and employed one or two apprentices and journeymen, the latter being graduate apprentices who were "free to journey" and set up their own craft businesses. In Italy, France, Germany, Switzerland and Britain, the Master Craftsmen formed themselves into Craft Guilds designed for their mutual protection. The simplicity of industrial structure is illustrated by the fact that in medieval Paris the 128 Guilds existing were made up of 5,000 Masters who collectively employed not more than 7,000 journeymen. In this essentially one-to-one, employer-employee relation, there was no great need for an elaborate management structure.

The most important change took place about 1750 when the perfection of the steam engine gave rise to large scale manufacturing which, in turn, called for the acquisition, organization and control of comparatively large capital and labor resources. During the industrial revolution the craftsmen who were not crafty enough to acquire the new machines were themselves employed by the new entrepreneurs.

In a more enlightened age, the demands of the mechanized industries of the late 18th and early 19th Centuries might have given rise to an effort to develop relevant managerial philosophies. It was not however until the 20th Century that the theory and practice of industrial management became a subject for serious study, by which time many unfortunate attitudes and practices had become ingrained.

The predominant purpose of the industrial revolution was to replace craftsmen with mechanical and technological devices in order to create more products at lower unit cost.

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Eventually, and as a direct consequence, managers developed a machine philosophy which barely, if at all, differentiated between men and machines, a philosophy inherited by several generations of their successors. In fact, the histories of the time clearly indicate that many employers displayed more concern for the well being of their machines than of their employees. Most of the early management studies were concerned with physical efficiency and regarded the human being as a machine rather than a living creature with an intelligent, creative mind and sensitive feelings.

The only models of management organization and practice available to leaders of the industrial revolution were governments, the army, and the church, all of which tended to be autocratic and authoritarian, ruling more by decree than through dialogue. As the industries grew, they borrowed from the army and the church the scalar or pyramidal system of organization. (For those interested, I would recommend James Mooney's "Principles of Organization" in which he presents a very comprehensive and sympathetic analysis of the church as a model of organization that demonstrates the scalar principle.)

As the industries became bigger, their organizations borrowed from the Prussian Army the organizational principle of staff and line functions. The "staff" officers were essentially administrators who carried the staff as a symbol of their office: the "line" officers were those who fought in the lines. Unfortunately, many management systems which have borrowed the army's system of organization overlooked or were ignorant of two fundamentals clearly understood and practiced by the 17th Century Brandenburgs and their successors the Prussians, namely that the best staff officers are those who have spent some time in the lines and second, that at all levels of the pyramidal scale, the extent and limits of authority are clearly defined and the responsibility vested in one person cannot exceed his authority.

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It is only comparatively recently that the larger business organizations have included in the training of their junior executives a period in both staff and line functions.

The British utilitarian philosophers of the 18th and 19th Century provided the intellectual justification for the style of personnel management which prevailed during the industrial revolution and exists in many organizations even today. Jeremy Bentham's philosophy of human behavior 'that pleasure is good and pain is bad'; 'that all men will seek pleasure rather than pain' was embraced by his contemporaries, the Mills brothers, James, John Stuart, and Dark Satanic. As a basis for management practices, it is essentially similar to Machiavelli's observations in "The Prince" which he wrote as a management guide for the Medici's in the 16th Century. Machiavelli proposed that states or men that are to be ruled must be either pampered or crushed; they are best motivated by the promise of material benefit or by the fear of punishment, a principle which in management circles today is known as "the carrot or the stick".

Adam Smith in his "Wealth of Nations" suggests that if we want something from other persons we should address ourselves to their "self-love" and not to their benevolence. Herbert Spencer, Thomas Malthus and Charles Darwin advanced the proposition that life is brutish and only the fittest deserve to survive.

Alexander Pope made poetry of utilitarianism when he wrote:
"Thus God and Nature form the general frame,
and bade self-love and social be the same."

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INDUSTRIAL MANAGEMENT

To my knowledge, the first major book on industrial management "Administration Industrielle et Générale" was written in 1916 by Henri Fayol, a remarkable French mining engineer. Fayol described the purpose of management as being "to encourage and direct change while maintaining contact and continuity with the past". He writes at length and with much insight on orderly vs. disorderly innovation.

Fayol's most notable legacy are his five basic functions of management:

1) Planning
2) Organization
3) Command
4) Coordination
5) Control

These, in one form or another, form the basis of most text books of management teaching.

The philosophical history of industrial management might be crudely classified into four overlapping periods.

1) The management of physical things, such as tools and machines, a phase that began during the industrial revolution and continued into the 20th Century;
2) The management of people, which occupied the first 40 years of this Century;
3) The management of money, which began when industrial accountants recognized that more is to be gained by imaginative forward budgeting than post-mortem auditing;
4) The management of ideas - a very recent concept among food and agricultural and other craft-derived industries, which recognizes that imaginative and creative thinking are not the sole competence and prerogative of those in highest authority.

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The management of physical things formed the original basis of industrial management and deserves little comment except that scientists are not immune from the machine, instrument or statistical concept of management.

The management of people for many decades was simply an extension of the management of machines. The first generation of industrial psychologists were really industrial physiologists descended in a direct line from Paracelsus who, in the 16th Century, studied industrial diseases, and Coulomb who, in the 18th Century, pioneered studies on work, movement and fatigue.

Though modern applied industrial psychology may have had its roots in the laboratory of Wilhelm Wundt at the University of Leipzig in the 1870s, the so-called industrial psychologists of the late 19th and early 20th Century were essentially physiological technicians concerned solely with human efficiency. Wundt's successors, from the 1930s until modern times, were concerned mainly with maximum output for minimum effort. Attention to environmental factors such as lighting, ventilation, air conditioning, MUZAC and coffee breaks had one primary purpose: to keep the workers reasonably content and to increase their per capita output.

Since physiological engineering was an extension of mechanical engineering, it is not surprising that all of the most prominent authorities on time and motion in the first part of this century were in fact engineers.

Frederick Winslow Taylor, the chief engineer at a Philadelphia iron works, developed standards by which to judge human efficiency and prescribed the most economic movements for any physical task. In his most famous experiment, Taylor found a Dutchman who, following Taylor's instructions, increased his rate of loading pig iron into trucks from 12½ tons to 47½ tons per day. Using the Dutchman as a

model to be copied by other workers, Taylor reduced the number of employees from 500 to 140 and increased the company's profits by $75,000 in the first year.

Frank Gilbreth quantified time and motion studies and described 17 fundamental hand motions, starting with "search" and ending with "rest", that are employed in most manual operations. His units of manual dexterity he called "Therbligs" which is his name, Gilbreth, spelled backwards. (For anyone interested, Gilbreth's work is described in Bond's "Motion and Time Study" published by Wiley in 1958.)

Elton Mayo in the late 1920s at the Hawthorn works of General Electric, was among the first to demonstrate that factory workers have minds as well as bodies. Mayo studied the influence of changes in working conditions on the productivity of women producing component parts for Bell Telephone. Mayo systematically introduced improvements in lighting, comfort, the frequency and length of rest breaks, shorter working hours and time off. With every apparent improvement the women's productivity increased. Finally, Mayo reintroduced the exact conditions which existed at the beginning of the experiment. Production increased still further.

Stuart Chase, in his books "The Proper Study of Mankind" and "Man at Work", is one of many who reviewed Mayo's work. Chase suggests that production was increased even when conditions were returned to the original because of a fundamental change in the women's attitude to their work. Chase states: "By asking their help and cooperation the investigators made the girls feel important. Their attitudes changed from that of separate cogs in a machine to that of a congenial group trying to help the company solve a problem". It was explicit in Mayo's experiments that before every change the women were consulted and their comments invited. Other writers have however suggested

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that Mayo's experiments simply demonstrate the principle that the very fact of observing a human activity will of itself bring about a change in those being observed.

THEORY X AND THEORY Y

In one of the most interesting books on management "The Human Side of Enterprise", Douglas MacGregor of the Sloan School of Management at MIT, presents two extreme and opposed systems of management which he calls Theory X and Theory Y.

Theory X presents the traditional and utilitarian assumption that:

1) Man dislikes work and will avoid it wherever possible.
2) Man must be coherced to work by threat of punishment or deprivation.
3) Workers have little ambition, they avoid responsibility and prefer direction to self-motivation.

MacGregor's Theory X is a restatement of Machiavelli's and the carrot and the stick theory.

In contradiction, MacGregor describes Theory Y as the integration of individual and organizational goals in which the assumptions are:

1) Physical and mental work come as naturally as play or rest.
2) Work is a source of satisfaction.
3) Man will exercise self-direction and self-control when his personal objectives coincide with those of the organization.
4) Man's commitment is directly related to his sense of self fulfillment.
5) Man not only accepts, but seeks responsibility.
6) Imagination, ingenuity and creativity are widely distributed among people.
7) The intellectual capacity of most workers is underutilized.

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Some critics suggest that Theory Y implies everyone doing his own thing, the eventual result being total anarchy. MacGregor however, states explicitly that once an organization's objectives and methods have been collectively defined, a very rigorous corporate- and self-discipline is essential to ensure that everyone plays his agreed part. As Robert Stanfield said in his recent valedictory address: "Those who are not prepared to play according to the team's rules will be assigned to the bench and, if they persist, they will be put on waivers". Or, in the words of an earlier writer: "From those unto whom much is given, much will be expected, and the more they have entrusted to them, the more they will be required to repay".

The relevant and extensive literature quotes many definitions of "management". The one I prefer is derived from MacGregor's Theory Y: "To achieve clearly defined objectives through the willing cooperation of all the people involved".

MacGregor makes the valuable proposal that the most important element in management training should be a greater awareness of what he calls social interaction: the ability to communicate with, to influence and be influenced by others in the organization.

Within a research organization which seeks to employ creative professionally trained minds, one might expect participatory democracy to be the rule rather than the exception. Such is not always the case in either developed or less developed research institutions. While this is an attitude of mind and style that we cannot impose upon those we are seeking to help, we can encourage it by our own style of operation: in the first place by not being dominating or abrasive and in the second by requesting permission to discuss the project proposed with as many as possible of the scientists, particularly the junior scientists, who are to be involved.

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Recently the emphasis in management has shifted from studies of the isolated individual and his physical environment to a consideration of motivation and morale of groups of workers and in particular the emotional attitudes of workers towards one another and collectively to what is called by the unions "management". It was Edmund Burke who, in the 18th Century, wrote that: "No men can act in concert who do not act with confidence; no men can act in confidence who are not bound together with common opinions, common affections, and common interests". Perhaps the greatest difficulty common to all management is to create and maintain a communion of collective and creative confidence in mutually agreed objectives and the means of achieving them.

ELEMENTS OF INDUSTRIAL MANAGEMENT

There are three essential components of any industrial enterprise: Marketing, Production and Finance. To many the term Marketing tends to be confused with the techniques of selling. Marketing is however concerned with a much broader range of interlinked activities of which selling is only one. Marketing is primarily directed to satisfying a human demand. It begins by determining first, who is making the demand, second, what product or service are they demanding, and third, how much are they prepared to pay for it. In commercial jargon, the first is called 'Market or Customer Identification' and the second and third 'Product Definition'. Consequently, industrial research begins in the market place with the customer, not in the laboratory with the scientist.

Market or customer identification seeks to define the scope of the potential market, who precisely are the customers to be served, where do they live, what is their range of income, how many of them are there, what do they want, where, when and in what form do they want it, how much can they afford to pay

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for it; and with what other products or services will it be in competition. Though marketing is primarily an activity practiced by commercial industries, the underlying principles are, I believe, worthy of study by every applied research scientist. A great many non-commercial applied research agencies and institutions tend to think only in terms of production, occasionally about finance, and rarely about marketing in its broadest concept. In fact, where they do think about marketing their research product, it tends to be in terms of selling techniques, an attitude of mind which gives rise to such statements as: "Extension starts three years after research".

COMPONENTS OF MANAGEMENT

During the 30 or 40 years that management has been taught as a formal subject, many of the text books have emphasized Fayol's essential five components:

1) Planning - A definition of the ultimate ends, goals, purposes, or objectives and the means, methods or methodology by which to achieve them;
2) Organization of Resources - The human, physical (land, buildings, machines, equipment and supplies), and financial resources essential to the project;
3) Direction and Control - The executive and decision making functions;
4) Coordination - Which is largely concerned with communications; and
5) Monitoring - Which includes auditing, process and quality control, and which indicates how well the plan was pursued and the defined end realized.

SYSTEMS MANAGEMENT

A new school of "Systems Management" has recently made its appearance. Systems management should not be confused with "Systems Engineering" which includes such tools of management as mathematical, graphic and mechanical systems of control,

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monitoring and forecasting as exemplified by linear and non-linear programming, supported by computer technologies. Though in some respects their differences with the managers of the classical Drucker school are largely semantic, systems managers present generally a more comprehensive and thoughtful approach to the study and practice of management. Rather than thinking in terms of a sequence of activities, whether it be a project, a program or an institution, they try to observe the system as a whole: its interaction with related and contiguous systems, and in comparison with ideal, optimum or model systems. They speak of "problem oriented systems approach", and the elements of their study pursue the following general sequence: (SEE FIGURE 1)

1) Problem Identification - which entails detailing the elements of the problem and the "environment" in which the problem system exists. The Systems Approach argues against an overly simplistic view which sees each research problem as an isolated phenomenon with a purely technical objective. Systems managers would not define as a problem the introduction of high methionine genes into rhubarb: rather, they would examine the complex set of systems relevant to improving the nutritional well-being of an identified malnourished population.

2) Analysis - which includes a detailed study of "the environment"; the elements of structure - the static members or framework of the system, and the elements of process - the dynamic, operational aspects of the system.

3) Root Definition of the System - which seeks to identify and quantify the nature and interaction of all other systems relevant to the problem system. If they were studying a problem in an IARC, the Systems Manager would examine the existing physical and organizational structure; the IARC's defined purpose compared with its actual orientation; the IARC's on-going activities in comparison with its defined purpose; its interaction with related competing and cooperating research systems such as other IARCs; its related information, communication, application and extension systems; its own and complementary training systems; its monitoring and evaluation systems; the influence of the CGIAR and TAC systems upon its own and related activities. (SEE FIGURE 2)

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4) Conceptualization - this unfortunate example of modern jargon probably means "creative thinking", the purpose of the exercise being to create in the mind the optimum or model system in terms of the most economical sequence of activities necessary to solve the problem.

5) Comparison - The optimum model is compared in the mind with the existing system.

6) Definition - This requires the construction on paper of a pragmatic model that is a workable hybrid derived from a comparison between the ideal model and the existing set of circumstances.

7) Design - This calls for a detailed plan of action, including an inventory of the resources necessary compared with those available and the placing of the whole proposed exercise on a timetable or network chart showing clearly all the points of input and output together with the planned points of monitoring, feedback and re-analysis.

8) Implementation - This entails putting the pragmatic model to the test on a pilot and/or full-scale basis.

9) Appraisal - This calls for a continuing process of monitoring and evaluation of what was conceived, and what in fact results.

The systems management experts insist that the foregoing nine activities are not discrete and separate but that they overlap and merge at all points.

The diagram in Figure 3, which on first view appears as pop-art is representative of the Systems Managers' concept of their diagramatic approach to management.

Some of the writings of the systems management school may at first seem to be academic and fussy, and some of the terminology suggests old wine in new bottles. Nevertheless, the intellectual approach is one that research directors could usefully study, since its purpose is to position and examine each problem or activity in its larger context, not in abstract isolation.

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TECHNOLOGICAL FORECASTING

Another recent school, an offshoot of systems management, is called "Technological Forecasting". Its exponents seek to make things happen. Another name might be "technological self-fulfilling prophecies". Technological forecasting should not however be confused with the proving of a hypothesis by fudging of the experimental data.

The TF experts consider technology in four successive stages:

1) Innovation; 2) Diffusion; 3) Adoption; 4) Benefit

Technological Forecasting lays greatest emphasis upon diffusion and adoption - the "Delivery Systems". Though some TF experts employ esoteric econometric models, in large part they have borrowed and refined the best techniques of market research. Essentially TF looks at the whole system from innovation to adoption and in common with good market research, it starts by defining in very precise terms what is the technology of product of technology needed and who, precisely, is it that needs it. Consequently, the best examples of TF begin not in the research centre but in the technological market place.

In common with other intellectual movements, the TF people have their own vocabulary, the adoption process being presented in five successive stages:

1) Awareness; 2) Interest; 3) Trial; 4) Evaluation; 5) Acceptance.

THE HULSE MODEL

Having reviewed historically what I believe to be the origins and major influences upon present management theories and practices, it seemed incumbent upon me to present my own working hypothesis.

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Having once studied with Dr. Bellamy, the originator of the concentric theory of teaching, I am impressed that evolutionary progress is better understood as a series of concentric circles or an expanding spiral than as a continuous straight line. Since my concept of management is a continuously expanding circular function, it is presented as a circle in the diagram in Figure 4. I would emphasize that it should be regarded as essentially dynamic and expanding, not as a static concept.

The essential components of this model are:

1) The Beneficiary - Who will benefit?

2) The Rationale - Why is the program or project necessary?

3) The Objective - What is the end purpose?

4) The Means or Method - How is the objective to be achieved?

5) The Resources - By whom and with what are the means to be executed?

Surrounding the project system is the environment (borrowed from the Systems Managers) and at the hub one finds the control, monitoring, communication, information and memory functions.

1) The Beneficiary

The most important component is the beneficiary - the people the research is destined to benefit. The beneficiary, or customer, is central to marketing research and I believe to all applied research. Sadly, "the beneficiary" rarely appears in non-industrial applied research or even as a component of general management theory. I would propose that applied research has very little meaning if the beneficiary and the means by which the benefit is to be delivered are not clearly defined by all of the criteria listed earlier under "Consumer Identification".

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It is fundamental to this approach that the beneficiaries be consulted and that they contribute to the definition of the objectives and to the evaluation of the results. Similarly, in marketing research, it is only through detailed discussions with customers that the end product and the delivery system can be defined. As suggested earlier, the beneficiary or "end-user" concept is also basic to technological forecasting systems.

2) The Rationale

The fundamental question to be answered is how will the beneficiaries be satisfied more efficiently and economically by the particular research project proposed than by an equivalent or lesser investment of effort and resources in some other activity?

About a year ago, a reputable foundation proposed to invest about $13 million in a cattle ranching research project in Niger. The proposal collapsed after an astute person pointed out that all of the Nigerians who could possibly benefit from such a project during the next ten years would be far better off if the $13 million were invested in high interest bonds and the proceeds distributed. Research, particularly when defined in narrow scientific objectives, is by no means the panacea for all ills. Mindless and disoriented propositions hurt not only themselves, but many more worthy research proposals.

If the end purpose of a research proposal is not expressed in terms of a human demand or need, be it the shareholders demand for higher profits, the farmers' need for a higher income, or the malnourished child's need for a more adequate diet, the rationale may amount to little more than the ambition of the scientist to present the results in a paper to a learned society. It is unfortunate to witness now many government research workers seem motivated mainly by the desire to impress other scientists rather than to serve some human need.

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In evaluating a proposal we need to make sure it is not simply a duplication of what is going on elsewhere. Some degree of duplication may be desirable as illustrated by I.G. Farben, one of the most successful chemical companies of Europe, who deliberately encourage competition within their own organization. IGF often employs two or three independent research teams to work on the same problem simply to generate a sense of competition or urgency in the knowledge that both the race and the reward go to the swiftest. Nevertheless, among the LDCs, excessive duplication has to be avoided, if for no other reason than to make the best use of limited scientific manpower.

3) The Objective

It is probable that more has been written and less understood about the definition of objectives or end purposes than any other aspect of management. Einstein summed it up when he said that man's problem is that he exists with a perfection of means, but with a confusion of ends. This is apparent in project proposals in which the objectives have clearly been dictated by the technical means available. The objectives in applied research cannot be defined until the beneficiaries' need or demand has first been identified and analyzed.

The objectives of every project must be reviewed in the light of the overall objectives and competence of the institution proposing to carry it out. Project objectives should not be inconsistent with corporate or institutional objectives. In defining institutional and project objectives, particularly in LDCs, one must consider on whom else they depend other than the scientists and technologists employed by the institution. One must take into account the capabilities of the scientists in the institution and the facilities available in deciding whether the research is to be creative or adaptive. If it is to be adaptive, it will be dependent upon somebody else's creativity.

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Even if it is to be creative, it may well be dependent upon other sources of new or existing knowledge. Even the IARCs are not equipped to tackle the many fundamental problems they encounter.

While it may be difficult to define project objectives, it is infinitely more difficult to define institutional or corporate objectives. The primary objective of private industry is to make money for shareholders by the profitable sale of goods and services. Proctor and Gamble are in business to make money, not to make soap. Nevertheless, it is probable that several US railroads went bankrupt because they thought they were in the railroad business while at the same time, Canadian Pacific made money because its directors realized it was in the transportation business. It is enlightening to probe with Directors of research institutions what they consider to be their institutional objectives: then to ask the same questions of the research staff, the Board of Trustees, and finally the proposed beneficiaries - if indeed these can be identified.

One of our recent visitors said that the purpose of IDRC is to give away taxpayer's money. If this is so, we are obviously greatly overstaffed. The fact remains we do give away money so the question we should ask ourselves therefore is: "What in precise terms is our primary objective if it is not simply to give away money?"

It is not readily apparent that all of the IARCs have defined their objectives in other than technical and scientific terms. Direct benefits to under-privileged people tend to be implicit rather than explicit in their publications.

If, through offering money, IDRC's primary objective is to stimulate applied research for the benefit of the under-privileged, we need to consider carefully at what level of research the money under our control should be directed. The conventional four steps of applied research described by the Technological Forecasting are: innovation; diffusion; adoption and benefit. An oversimplified model showing the relation between fundamental, applied and adaptive

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research is displayed in Figure 5. It suggests that major innovation results from the cooperative efforts of universities in developed countries and the IARCs; diffusion between the IARCs and national research institutions; and adoption and benefit largely through cooperation between national institutions and local farming communities. The question facing us is upon which of the components of the agricultural research sequence should we concentrate? As we shall demonstrate later, the largest operating costs and the greatest rate of cash flow is to be found in the IARCs. Therefore, bearing in mind our reduced cash resource, should we cut back on our support to the IARCs and increase support to strengthen links between the IARCs and national institutions and to stimulate growth within the national centres?

4) The Means or Method

I have already dwelled upon the dangers of ends being dictated by the means; the objectives defined by the methodology available. Had we but worlds enough and time, it would be interesting to examine how many of the proposed methodologies submitted in projects we consider are truly innovative and how many are simply cookbook. If the objectives are expressed in terms of a clearly defined human need, the methodology must perforce be specially designed since each human need exists in its own environment. If on the other hand, the scientist's purpose is to apply a set of acquired techniques, he or she can argue backwards from the techniques and define the objectives in purely technical terms.

Universities' assessments of "institutional quality" is probably largely judged on the strength of graduate teaching and the ability to produce PhD thesis. I suspect that there is a considerable degree of rigidity and inflexibility in methodologies in the field of food and agricultural research since it is easier to use that which is familiar than to be

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truly creative. It would be interesting to determine how many of the IARCs are being truly creative in their methodology as distinct from using repetitive and adaptive methodologies they learned in university.

In a project designed to serve a human need, the methodology must include the means by which it is proposed to deliver the results of the research to the beneficiary. In future project proposals, we shall look for more detailed information about how the results are to be diffused and adopted and the benefits realized.

5) The Resources

Having defined the methodology or means by which the plan will be executed, the next step is to quantify the resources needed and to compare them against an inventory of the resources available. Management is in large part the management of resources and the text books usually list three essential resource categories: 1) Human; 2) Physical and material; 3) Financial. I would submit there are four; the one not usually mentioned by the text books being Time. Any project or program which is not planned and monitored along a carefully calculated time scale will at worst be meaningless and chaotic and at best wasteful of the other three tangible resources.

A planned time scale is essential:

a) for budgetary planning and to determine the rate and critical points of cash flow, income and expenditure;

b) for coordination of the sequential activities with those in other related projects;

c) to maintain a sense of urgency and to ensure the benefit is delivered in the time required.

Research projects have a habit of going on forever; it is easier for directors to decide when to start a project than when to stop it. A time scale input chart illustrates first the points in time at which the various human material and

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financial resources will be needed and, second, whether all the resources necessary can be assembled, organized and put into operation within the time available.

From this point on, I am going to ask that all Project Summaries be presented as a planned time sequence with a clear indication of when each of the budgeted activities is scheduled to take place. (The kind of schedule necessary is a more specialized form of the network charts to be found in GRB's office.)

Human Resources

Research is a human activity and its success or failure depends more on people than on equipment. It is therefore a little surprising that in comparatively few Project Summaries or evaluations do we receive a critical appraisal of the professional competence and human qualities of the scientists we support.

The literature which relates to personnel selection is both amazing and amusing, particularly when one views the attempts of the psychoanalysts to predict the performance of any human being in any particular job. No doubt most of us have read William Whyte's "The Organization Man". I recently enquired of a number of industrial research organizations how they select, train and evaluate their scientific staff.

It was soon apparent that there is a wide divergence among different companies in their methods of both staff selection and appraisal. Within companies the systems have varied greatly over the years between highly formal systems with a lot of printed forms and almost completely informal conversational approaches.

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One of the major obstacles to efficient selection is a poor definition of what the job entails. If the essential components of the job are not defined, it is impossible to specify the qualifications of the person needed to fill it! Generally speaking, far too little thought is given to the albeit very difficult task of job description.

In our general discussions with potential recipients, and this applies just as much to international centres as to small university projects, it is worthwhile to discover how the research manager goes about selecting his staff. It is equally important to find out how he goes about briefing them for their task and what facilities for training and staff development exists, particularly for the more junior inexperienced people.

It would be very valuable when assessing project proposals to make a confidential critical evaluation of the Director of the Institute and the project leader, not simply as scientists but as managers.

The Research Manager

It is axiomatic that the first essential of doing a research manager's job well is the wish of the manager to succeed. However, this does presuppose a danger of making the objective happen even though the scientific facts are all against it. It is a favorite trick in industry to use research to prove what it wants to demonstrate. This is a trap into which we and those we support can fall if we are not scrupulously vigilant.

Though research means essentially taking risks, a wise research manager, particularly in the early days of his organization, will seek to balance a program which contains a mixture of comparatively low risk short term ventures with more long term high risk activities. The first can satisfy his financial supporters that they are getting something for their money whereas the latter, one hopes, will lead to the larger and more impressive payoff.

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In our pre-project discussions with potential recipients we can help them, through our experience, to assess the degree of risk in the project proposed. Young, inexperienced scientists should be discouraged from high risk ventures, if for no other reason, because it is discouraging to fail in the first research endeavours.

In "The Dialogues" Plato quotes Socrates as saying that the ability to preside or manage is inherent in a person; "A man will be a good President whether he has the direction of a chorus, a family, a city or an army." The Lamontagne report on Science Policy states "A research manager must be primarily a good manager rather than a researcher." A recent survey by the Canadian Public Service Commission indicates that more than 80% of the research managers in the government service progress simply by promotion from the laboratory bench or experimental plot and less than 20% have had either management or any other experience outside university and government research.

It is the conventional wisdom that scientists in general make poor managers, largely because they are presumed to have too narrow a focus of interest. I don't believe this need be so. If we accept that research is a logical and systematic process from the known into the unknown, and that research is devoted to the future rather than the past, scientists ought to make good managers. It is probably true however, as the Lamontagne report suggests, that science courses in universities give little if any attention to the management of human, financial, or even physical resources, if one excludes manipulation of scientific instruments.

There exists a substantial body of literature on the theory and practice of management which is not beyond the comprehension of any intelligent scientist who is willing to study it. I believe, however, there is an urgent need for formal training in research management, particularly for the project leaders and middle managers of the IARCs and national research institutions in developing countries.

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The Public Service Commission now offers research management training for scientists in the Canadian government service. However, from the two course curricula I have seen, they appear to be more in the nature of ad hoc management conferences with invited speakers rather than intensive structured courses such as are presented by the American Management Association, the Industrial Research Institute in the U.S., the Harvard Business School and other major universities.

It has been suggested by one eminent writer, Roger Falk, that a manager need not possess an outstanding intellect but rather an ability, born of self-discipline, to define clearly the objectives of his organization, to set them in an order of rational priority and to remember, and to help all others to remember what that order of priority is. Falk proposes that the management function may be weakened by a person having too great or too highly specialized a technical background. The problem of over-specialization is that the manager tends to think of all problems in the light of his own specialization rather than in a detached and comprehensive fashion. It may be for this reason that one finds very few research scientists in Canada as presidents of companies. To my knowledge, there is not a single president of a food or agricultural industry in Canada who started life as a research scientist. It is interesting that two IARCs have appointed, as Director-General, men who make no claim to a research background. Frankly, I do not accept that a good scientist cannot become a good manager, provided that he or she will cultivate the self-discipline necessary to the task, and learn to think of objectives in other than purely technical terms and whom the research is seeking to benefit.

Though there is no orderly body of knowledge related to management such as there is to plant genetics or biochemistry, the principles and practice of management is based upon a large body of collective wisdom and experience and can be studied by people who genuinely wish to improve their management capability.

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Many writers make a great fuss about management as a decision making activity. Certainly an indecisive or vacillating person rarely makes a good manager but confidence and ability to make decisions generally improves with experience and the factors to be considered can for the most part be learned. Though the courage and determination to stand by one's principles and decisions is essential, the qualities of compassion and humility may be more important in a manager than an exceptional intellect. There is no infallible specification or blueprint for the perfect manager. However, one who is concerned primarily with things or with himself rather than with others is not likely to be one of the best.

Anyone who has read Book 2 of Milton's Paradise Lost will recognize four managerial prototypes, reproductions of which are to be found in almost every field of human endeavour. You will recall than when the four angels were cast out of heaven, each proposed what action they should take in order to establish their diabolical enterprise.

The first, Molech,represents the typical bull at a gate manager; lots of drive and energy, but little analytical thought. The second, Belial, is the pessimist; primarily concerned with his own survival and keeping out of trouble. Mammon, of modest creativity and ambition, proposes to make the best of the hell they find themselves in and to gradually exploit it for their own benefit. Beelzebub, however, is the one of grandest design who is not content simply to develop cautiously and prudently but to proceed in the grand manner to find new worlds to conquer. He decides first to make a market survey before designing a sales campaign.

"There is a place...
Of some new race called man...
Thither let us bend all our thoughts,
To learn what creatures there inhabit,
Of what mould or substance, how endued,
And what their power, and where their weakness,
How attempted best, by force or subtlety."

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One of our most important jobs is to act as advisers to the policy makers and directors of research institutions in developing countries, many of whom are very isolated and lack access to a sympathetic and experienced person with whom to share their management difficulties. Our purpose should be not simply to review critically their experimental techniques and results, but to help them to become better research managers by discussing with them their general management problems.

Every manager needs reliable advice and counsel and in the case of the IARCs, I believe this should be one of the important functions of the Board of Trustees. It should be recognized however that such Boards give advice to the Director-General and it is for him to use this advice in the most appropriate manner. Committees can be extremely helpful as sources of advice, but as instruments of direction and execution, they are usually disastrous. We have seen one or two examples in the IARCs of Board of Trustees and also groups of donors trying to direct the centre from outside. If a Director is not functioning properly, he should be dismissed but he cannot be retained and partially replaced by an executing committee which seeks to overrule what he does or to make decisions contrary to his own.

In the projects we support, I believe we should encourage the use of advisory committees or other advisory services to the research directors and project leaders. I believe the cassava committee and the triticale committee have served an extremely useful function and made these projects far more effective than they would have been had the advice not existed. One useful function we can serve is to help young directors of research in developing countries to find and cultivate sources of advice relevant to their needs. Many of them probably feel

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very lonely and feel the need for a sympathetic and reliable source of advice. I repeat that it is one of our functions to provide such advice both from our own resources and by encouraging and facilitating access to others of relevant competence.

Structural Organization

Most enterprises and research institutions have an organization chart, the purpose of which is to display the level and extent of authority and responsibility of each employee. Most of these charts appear as a scalar pyramid with the Director at the top and the most junior at the bottom.

A few prefer to set out their organization in a horizontal pattern and, fewer still, make diagrams of concentric circles with the Director at the nucleus, the rest displayed like electrons or satellites in orbit around him. I propose to deal only with the scalar pyramid not because I consider it superior to the other two, but because it is the more familiar. SEE FIGURES 6, 7 and 8.

The subject of greatest debate is how many subordinates should report to a single manager; different writers suggest different magic numbers for the optimum span of command. William the Conqueror after 1066 established one of the most efficient systems of government in British history. In the Domesday Book he compiled the most detailed inventory of capital assets and anticipated revenue ever written. He administered his national estate through 10 senior landlords who reported directly to him. I believe that the Roman army was also organized in spans of 10. Some writers suggest that five and some eight is the optimum span of command. Frankly, I don't believe there is a universally perfect number, since it is dependent upon the nature of the work being done and how much direct supervision is required. If the

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number is too large, some components will tend to be neglected. On the other hand, if the number is too few, the manager may drive everybody mad by too close a scrutiny of their hour to hour activities.

An important aspect, often ignored, is the height of the pyramid and how far is the man at the top from the people at the bottom. The disasters on the Somme in the first world war can probably be attributed to the fact that the British high command didn't have the faintest idea what was going on in the trenches. The manager, particularly in a large organization, who is able to maintain contact with all levels of the pyramid is indeed a rare and exceptional person.

Antipathy and even conflict between research workers and the administrative staff is by no means unusual and this I believe is largely attributable to an organization in which the administrative staff and the controller's staff appear in separate boxes and at a different point of the organizational pyramid from the research staff. I fully share the view that administrative and accounting staff should be an integral part of each research team even if only on a part time basis. Such an arrangement is facilitated more by what I would call a functional organization rather than a disciplinary organization. SEE FIGURE 9.

In the functional organization of a research institution, teams drawn from different fields of specialization are brought together to do a specific job under a team leader. Since each team is dependent upon administrative services and financial support, it is logical that the people responsible for these services be included in the project team. Organization by project team seems more difficult to realize in universities than in non-academic research institutions, probably because

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of the rigid departmental structure which has been jealously guarded and has ossified over many years. Nevertheless, as was demonstrated in one of our projects, with a little persuasion, even universities can change their systems of organization and the efficiency with which they administer applied research projects, if they are willing to do so.

Financial Management - The Budget

I have been told more than once by research workers, "I am a scientist, not an accountant, therefore don't expect me to produce reliable budgets". My response to that is that since preparation and control of a budget involves nothing more than simple arithmetic, if a scientist is incapable of producing a budget, one can have little confidence in any numerical results or calculations derived from his experiments. Some of the budget forecasts of the IARCs give one serious doubts concerning the reliability of their other calculations.

In Figure 10 we have compared the budgets forecast two years ahead by the IARCs with the budgets actually presented when the years in question were arrived at. The exceptional differences cannot be explained simply by inflation.

A budget is simply a means of assigning cash values to a sequence of planned future activities. A budget is an extremely useful management tool in that it indicates the level of emphasis being placed among different components of a research program and shows the rate at which an institution and its program intend to proceed and to grow. A regular monthly comparison or forecast against actual expenditures provides a useful indication of how well the system is under control.

Some time ago we drew up a suggested budget format as a guide to potential recipients and I don't propose to go into the subject of budget categories. I would emphasize however that there is no model system but the budget should be relevant to the planned methodology and system of resource management

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adopted. However, the budget should be directly derived from the methodology proposed.

Ray Audet and Ed Zdyb have recently produced an excellent document entitled "Concept of a Management Information System for ICARDA" and I would recommend this to each of you for study. It emphasizes the point we have made several times that project or activity budgeting is far more precise and meaningful in a research organization than a disciplinary or even worse a common pot budget.

By a project budget we mean that each project or program within an international centre should have its own detailed budget. Some of the international centres started off with disciplinary budgets in which they budgeted so much for plant breeders, so much for agronomists, so much for entomologists, so much for biochemists, so much for agricultural engineers, etc. irrespective of how these people were to be employed within the Centre. They then tried to convert this to project budgeting by stating that x man days of plant breeders and y man days of agronomists would be required in a specific project. The difficulties of such a system is that only the Director General can be held accountable for the various activities and expenditures. Where each project has its own budget, each project leader is responsible and accountable and costs can be more correctly assigned.

The "common pot budget" is one in which in fact all of the operating funds are in a central kitty and everybody draws from it until the pot is empty. One need hardly comment upon the futility and in fact the irresponsibility of operating such a non-system, though such are by no means extinct even in comparatively large organizations.

Budgeting, in common with all other management activities, is concerned with the future, not the past. Though the commercial concepts of profit and cost may seem remote from an applied research organization, they are valid if we think of profit as future benefit and cost as present sacrifice. An important aspect of budgeting is to determine the least sacrifice required to achieve the greatest benefit. Some may prefer the concept of "Opportunity Costs" which conceive that by using the money available to finance one activity, one sacrifices the opportunity to finance something else.

Probably the simplest and most effective budget for research projects is a cash flow budget. However, since both expenditures and income are spread over a period of time, it should be a truly cash flow budget drawn up along a time scale axis which shows the category and level of disbursements against the forecast budget for each budgetary period. Ray Audet's publication presents a useful model.

I would strongly urge that when helping recipients to draw up a budget proposal, we insist that they present the details of proposed capital and operating expenditures along a time axis, broken down by months. Almost invariably where there is to be new staff, salaries are budgeted as though they start on the first day of the project whereas, in practice, almost invariably the staff are recruited sometime after the starting date. Similarly, capital expenditures are not all disbursed in the first months of the project since, particularly in developing countries, there is usually a long time lag between ordering and delivery of equipment and supplies. An examination of the recipient organization's past experience is often a useful guide in preparing the time-scale cash flow budget.

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One other point which is very well covered by the Audet paper concerns direct vs. indirect costs. Indirect costs usually appear in what is called "Overhead" or "Supporting Services". It is recognized that administrative and other supporting services are best allocated as indirect costs. However, there are many items which frequently appear under indirect costs which would be better expressed as direct costs. The Audet paper cites the case of vehicles and transportation which often appear as an indirect cost under 'motor pool' whereas in effect in many cases, vehicles are allocated to projects on a fulltime basis. In such a case, the vehicle, the driver and the cost of operation should all appear in the direct cost category.

The concept of fixed and variable costs is also important in a research project. Fixed costs are those which run on regardless of the level of output. In a research institution, one of the greatest influences upon fixed costs is the physical size of the institution and its facilities. Variable costs are those which increase in relation to output. The larger the number of trials or experiments, the larger the cost of raw materials and probably labor.

The industrial economist will probably tell us that fixed and variable costs are short run concepts, that in the long run it is possible to vary all inputs so there is no distinction between fixed and variable costs. However, the projects we support and most projects even in the IARCs, can be regarded as short run activities and therefore, the relation of fixed to variable costs has an important effect upon the total cost of operation. I emphasize this point since a great many institutions in developing countries have started off with a very heavy burden of fixed costs simply because such agencies as UNDP, the Bank and many bilateral donors, seek to unload all of their capital investment as quickly as possible. Consequently,

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one finds a great many food and agricultural research institutions including some of the IARCs, which are running at a very high level of fixed costs. The tendency towards heavy capital expenditures during the early years is common in many research organizations since there is an implicit prestige value in keeping up with the other scientific Jones in owning the latest model of this and that apparatus and in having at least as many hectares under test plots as they have. I raise this since it has a particular relevance to the initial capital budget of the project and the size of the facilities the institution will have to maintain after we pull out. We do the developing countries no service by providing excessive capital in the form of non-essential experimental equipment since it pushes up their fixed costs in terms of the space, ancillary services, and people required for operation and maintenance.

The Management Function

Having now gone round the circular model, I should like to finish with a few comments on the box in the middle which relates to coordination, communications and memory. Time does not permit more than a brief reference to the overall management function. I shall therefore deal with only two of the central elements: evaluation and communication.

Evaluation

One of the most difficult tasks of a research manager is monitoring and evaluation which essentially means judgment of how efficiently and effectively those responsible to him are working. The process of evaluation brings us back to a central figure of project management systems, namely the intended beneficiary.

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In industrial research, the judgment is fairly straightforward; how much has the workers efforts contributed to the profitability of the company. Based upon my experience of Canadian government research institutions, I don't know how much we have to teach to those of the less developed world in matters relating to the evaluation of human scientific effort.

The formal system, which appears to be coming into vogue in Canadian government departments, usually involves answering a lot of questions relating to each scientist's productivity, leadership, professional and personal qualities. In some instances, both the director of the establishment and each employee is asked to answer the same questions and then together, during a lengthy interview, they compare their responses. The advantage of a formal system is that an attempt is made to evaluate each employee's performance at least once a year. The difficulty is that most of the questions are couched in highly subjective terms and the results often appear more as judgment of the judge than of the judged.

Having read a number of these evaluation forms, I don't remember ever encountering the question: "In what manner has the Canadian economy or any section of the Canadian community benefited from this person's work?" Also, even where the evaluation forms are reviewed by a committee, in addition to the research director or the institute, the committee appears to be drawn entirely from the government department in question rather than being subjected to the scrutiny of say the farming or industrial community which the research is presumably supposed to serve.

In making our evaluation of the projects we support, I believe it is most useful first to obtain the evaluation of those who have carried out the research and as far as possible, those whom it is supposed to benefit. I hold the highly prejudiced view that research carried out in a purely government institution, financed entirely by public funds, stands a much smaller chance of being beneficial to the community than one in which some private interests of both a financial and policy making involvement are concerned. If a financial input from the farming or industrial community is not feasible, it does not preclude their having a voice in the evaluation.

Communications

Well coordinated management relies upon an efficient system of communication. In any management system which involves more than two people, including our own, the weakest component is usually the system of communication, communication not only with others in the same system but with other related systems and organizations, and also with the total surrounding environment.

Henri Fayol declared the most efficient method of communication was the weekly meeting of managers and a weekly report from those in the out-stations. In spite of the many elaborate tools available to us, we do not appear to have progressed much in improving communication systems since Fayol made this proposal during the 1890's.

While the system of communications with the present is generally weak, communications with the past and the future are even worse. Very few organizations I have had contact with have developed a reliable corporate memory. Most of us have been in AFNS for almost the entire life of the Division. Therefore, most of what has happened

is within the living memory. But what kind of memory base are we putting down for those who follow us? Many organizations simply present each new employee with all the relevant files and recommend he or she wade through them. This does not appear a particularly efficient or even effective process. I shall be grateful if you can suggest how we can improve our communications with the present, the past and the future.

Much has been written on "group dynamics" on which Herbert Bonner's book of that title in 1959 is perhaps the most interesting work, but I have not encountered any very imaginative alternatives to the internal memorandum, the conventional travel report and the periodic meeting. Nor am I convinced that the educational systems of the Western world are improving our capacity to communicate with one another in either the written or spoken word. It seems to me the style of the modern polysyllabists is much less precise than the earlier simpler styles proposed by Quiller-Couch, Ernest Gowers and Cervantes. Cervantes' dictum was that messages are most easily understood when they are written simply, clearly and concisely.

Perhaps at one of the future AFNS staff meetings we might devote a day to communications, communications among ourselves, communication with others of the present, the future and the past. We might also review to what extent our efforts to improve communications among scientists in LDCs in fields of common interest have been successful. How effective are the communications within the various networks we are supporting?

WHAT IS MANAGEMENT?

I started out asking the question, "What is Management?" and I don't know that I have done much more than suggest some things it is not. I would take issue however with many of the

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writers on scientific management who define the field in terms of solving problems. I believe it is more constructive and optimistic to think of management in terms of opportunities rather than problems. I agree with Francis Bacon that "The wise man will make more opportunities than he finds" and that people will work more enthusiastically in pursuit of opportunities than in the solution of problems. It is difficult to accept that two negatives do in fact make a positive and for this reason I believe donors prefer to contribute to crop production research rather than to the elimination of food spoilage. Increased agricultural production appears as an exciting opportunity; the elimination of waste as a depressing problem. The pursuit of opportunities encourage optimism, creativity and initiative. Those who think in terms of problems tend towards pessimism and to be ruled by their in-baskets.

It is therefore my firm conviction that we should think of research management as the pursuit of opportunities rather than the solution of a set of problems.

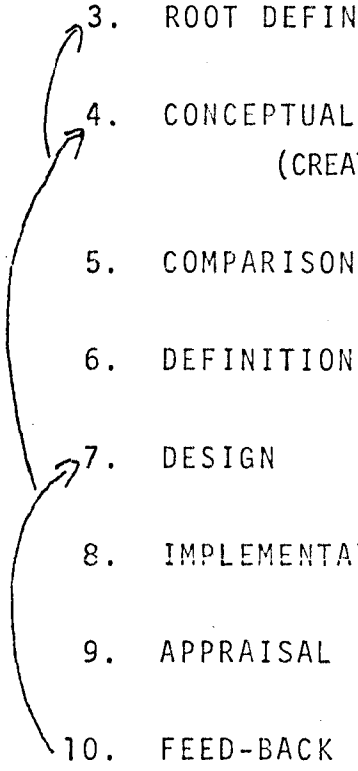
It was the Marquise du Deffano who wrote:

"La distance n'y fait rien: Il n'y a que le premier pas qui coute."

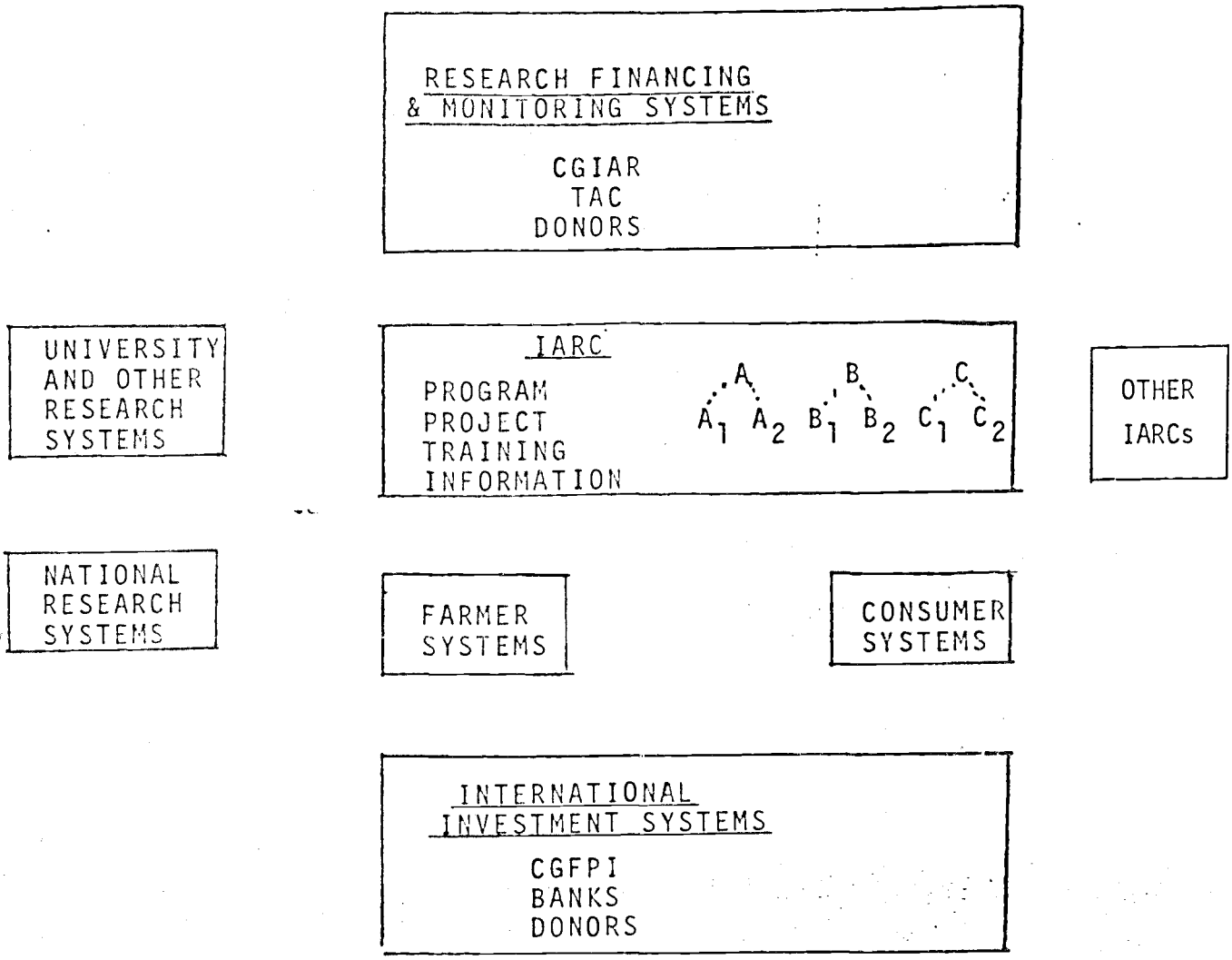
which can be translated as "The distance is nothing; only the first step is the problem".

SYSTEMS APPROACH

1. IDENTIFICATION OF THE PROBLEM
2. ANALYSIS
3. ROOT DEFINITION OF RELEVANT SYSTEMS
4. CONCEPTUALIZATION
   (CREATIVE THINKING)
5. COMPARISON
6. DEFINITION
7. DESIGN
8. IMPLEMENTATION
9. APPRAISAL
10. FEED-BACK



Figure


RESEARCH FINANCING
& MONITORING SYSTEMS
CGIAR
TAC
DONORS
UNIVERSITY AND OTHER RESEARCH SYSTEMS
IARC
PROGRAM
PROJECT
TRAINING
INFORMATION
A
A1 A2
B
B1 B2
C
C1 C2
OTHER IARCs
NATIONAL RESEARCH SYSTEMS
FARMER SYSTEMS
CONSUMER SYSTEMS
INTERNATIONAL INVESTMENT SYSTEMS
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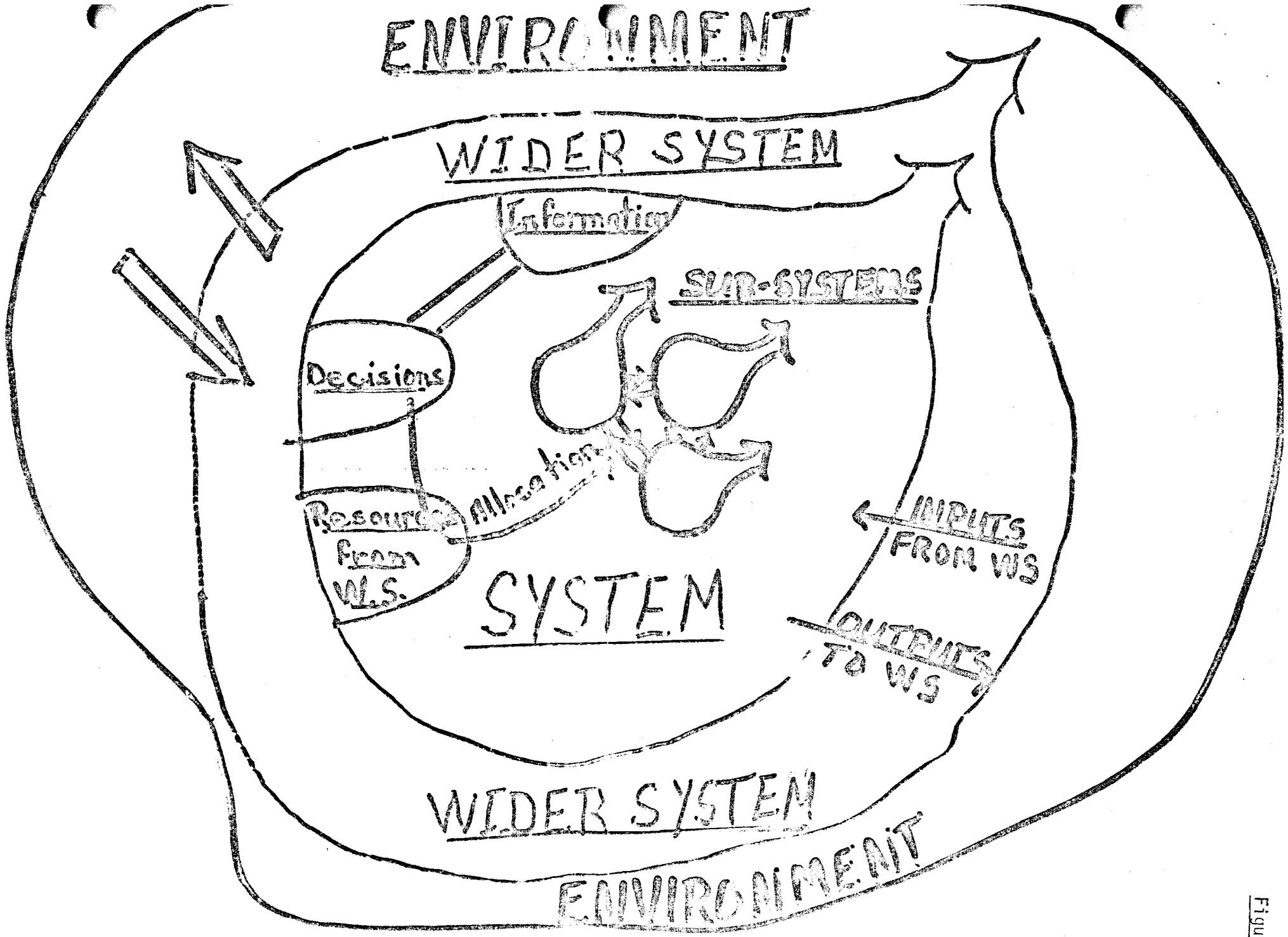
DONORS


ENVIRONMENT
WIDER SYSTEM
Information
SUB-SYSTEMS
Decisions
Allocation
Resources from W.S.
SYSTEM
INPUTS FROM WS
OUTPUTS TO WS
WIDER SYSTEM
ENVIRONMENT

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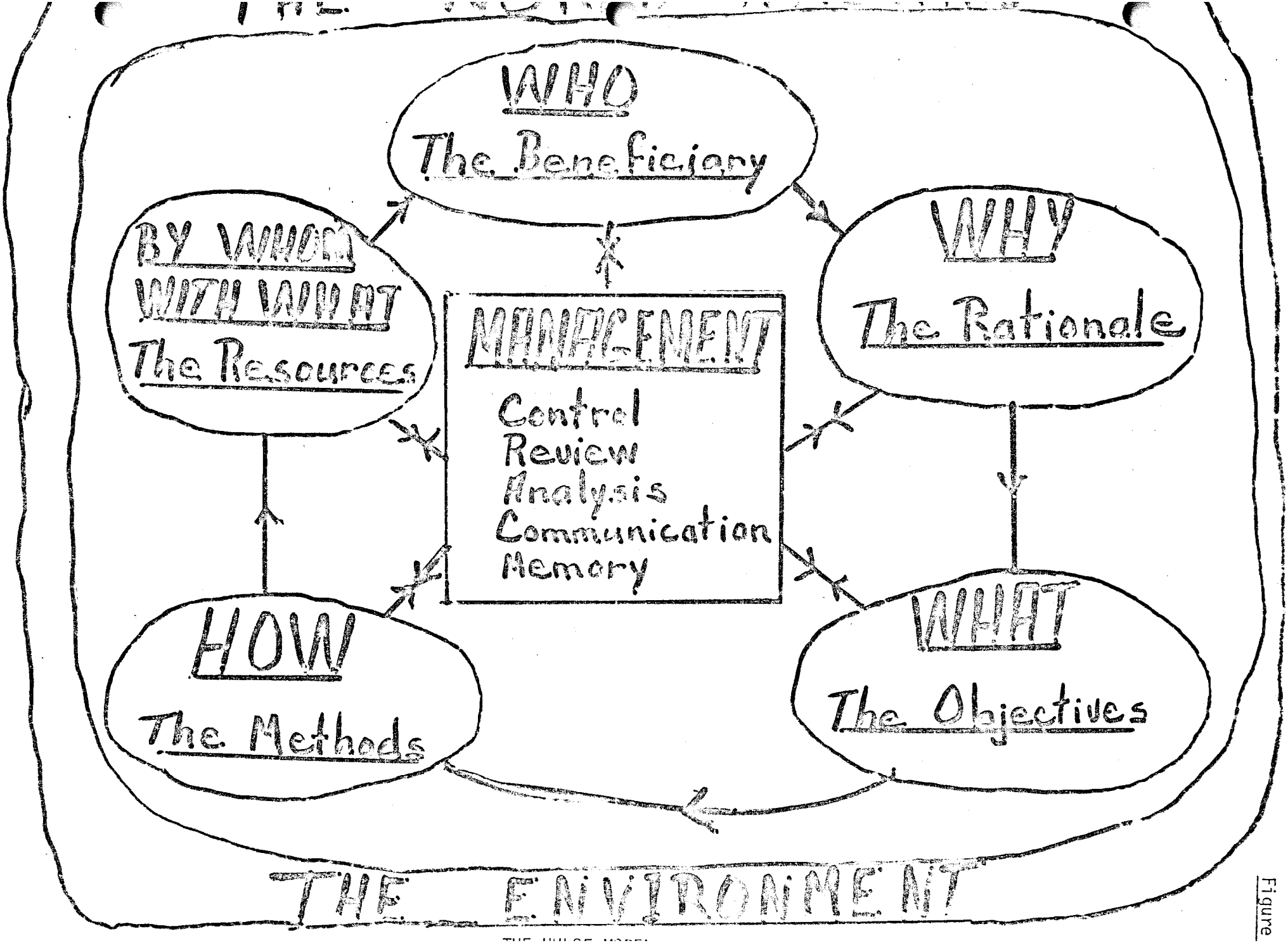
WHO
The Beneficiary
WHY
The Rationale
BY WHOM
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The Resources
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Control
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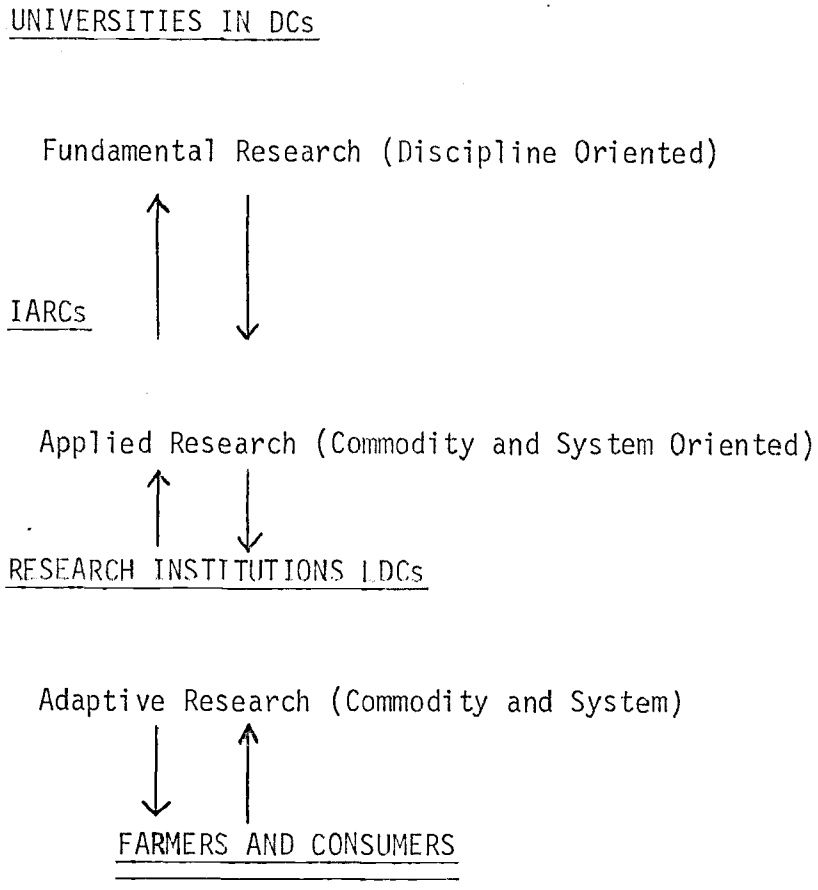
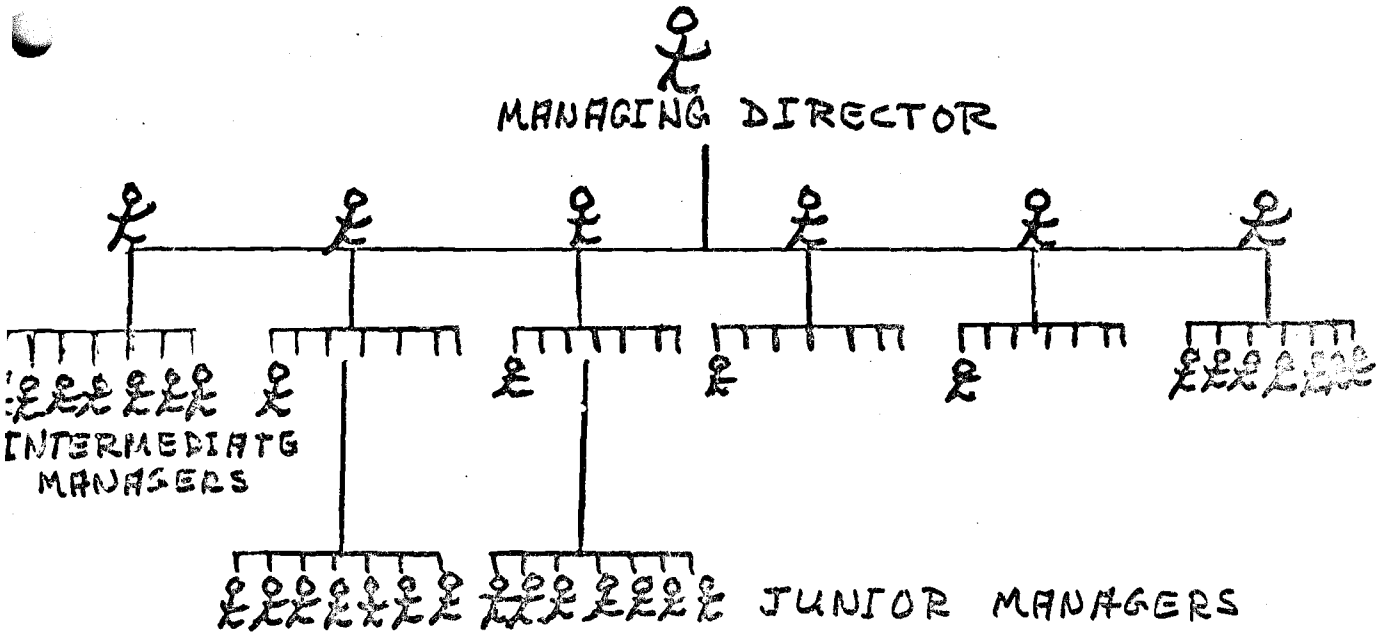
Communication
Memory
HOW
The Methods
WHAT
The Objectives
THE ENVIRONMENT

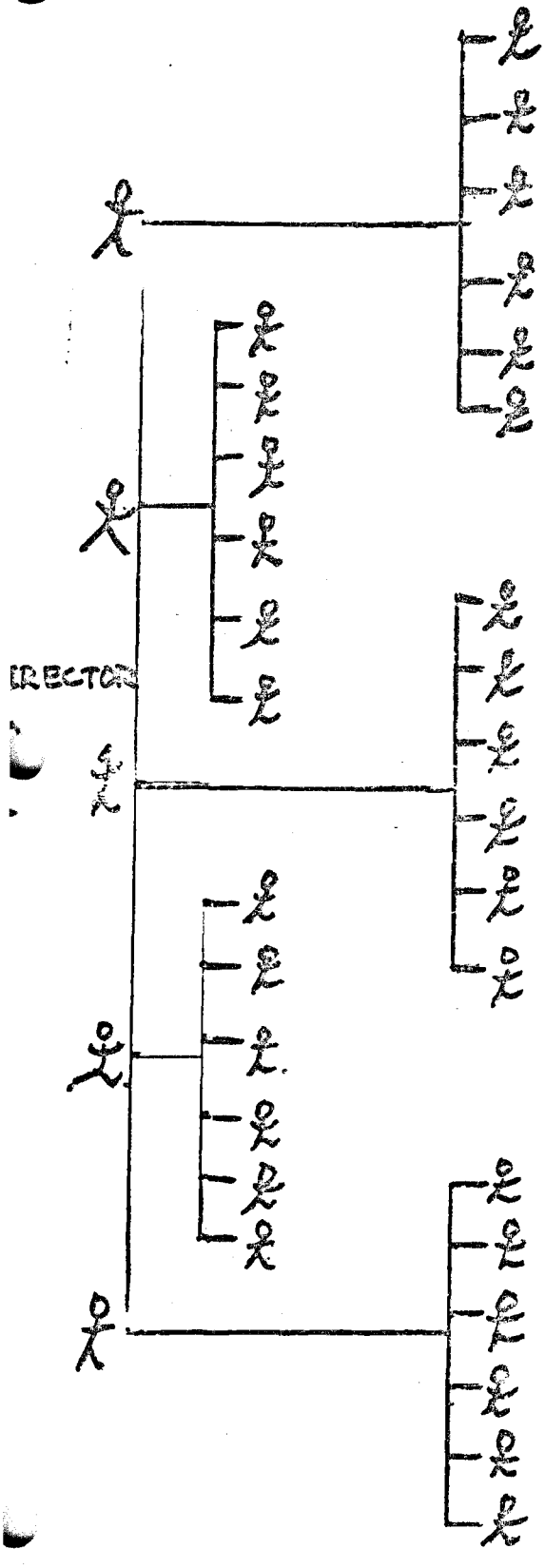
Figure


UNIVERSITIES IN DCs
Fundamental Research (Discipline Oriented)
IARCs
Applied Research (Commodity and System Oriented)
RESEARCH INSTITUTIONS LDCs
Adaptive Research (Commodity and System)
FARMERS AND CONSUMERS

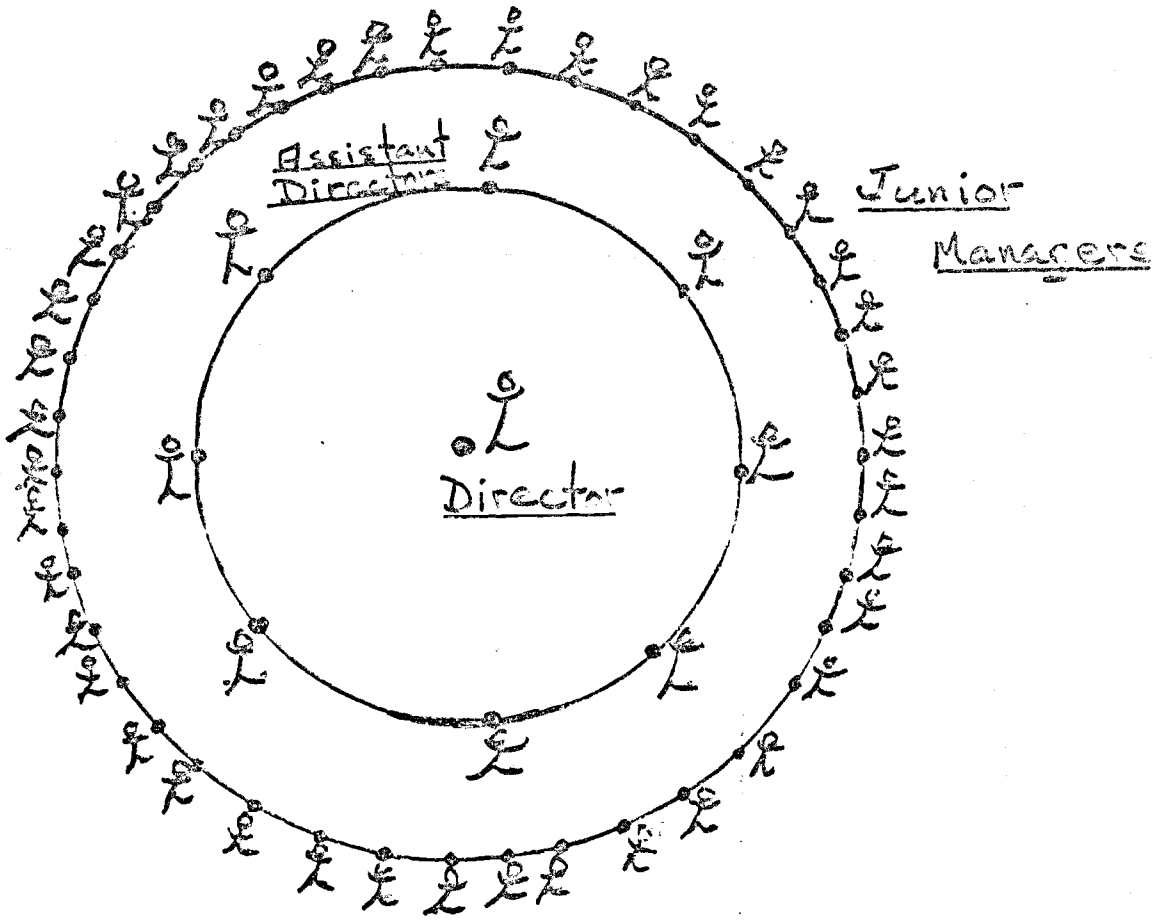
SCALAR PYRAMID



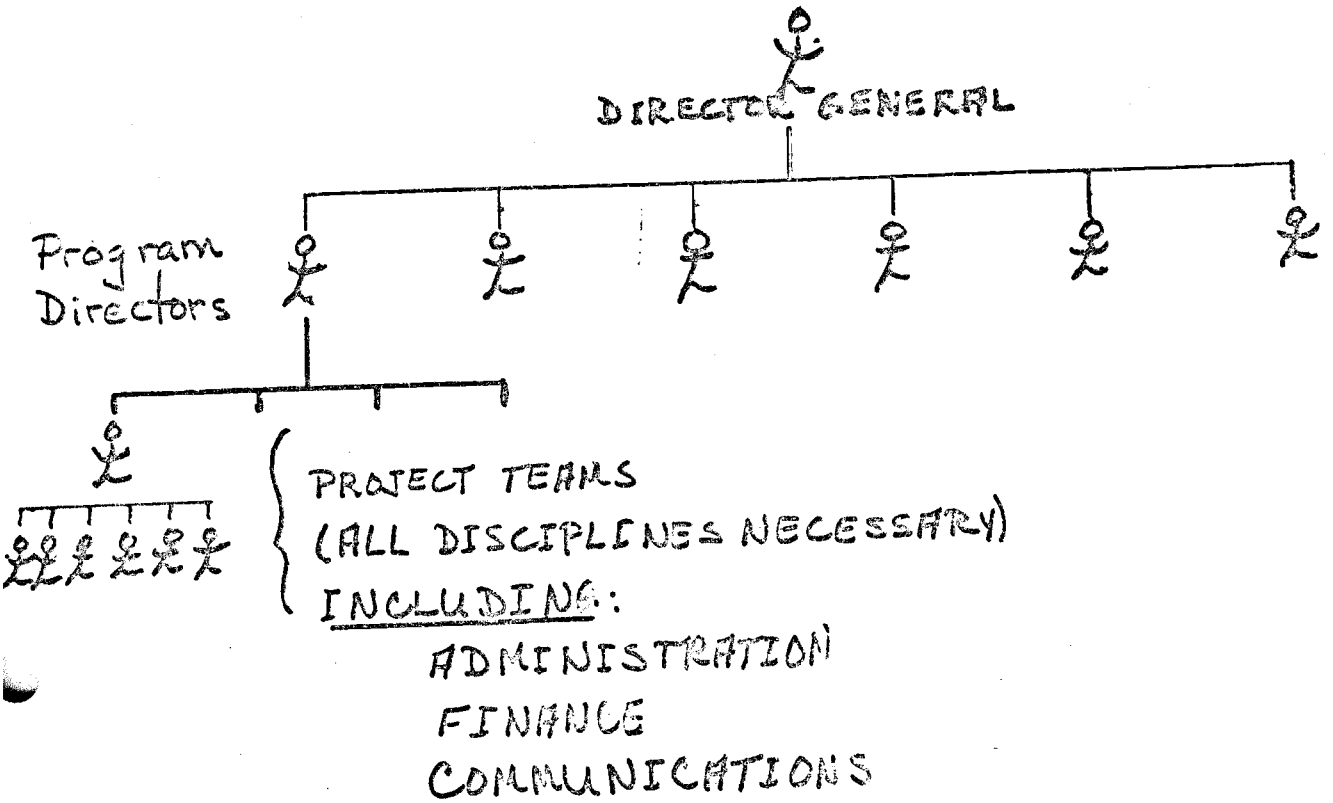
HORIZONTAL ORGANIZATION



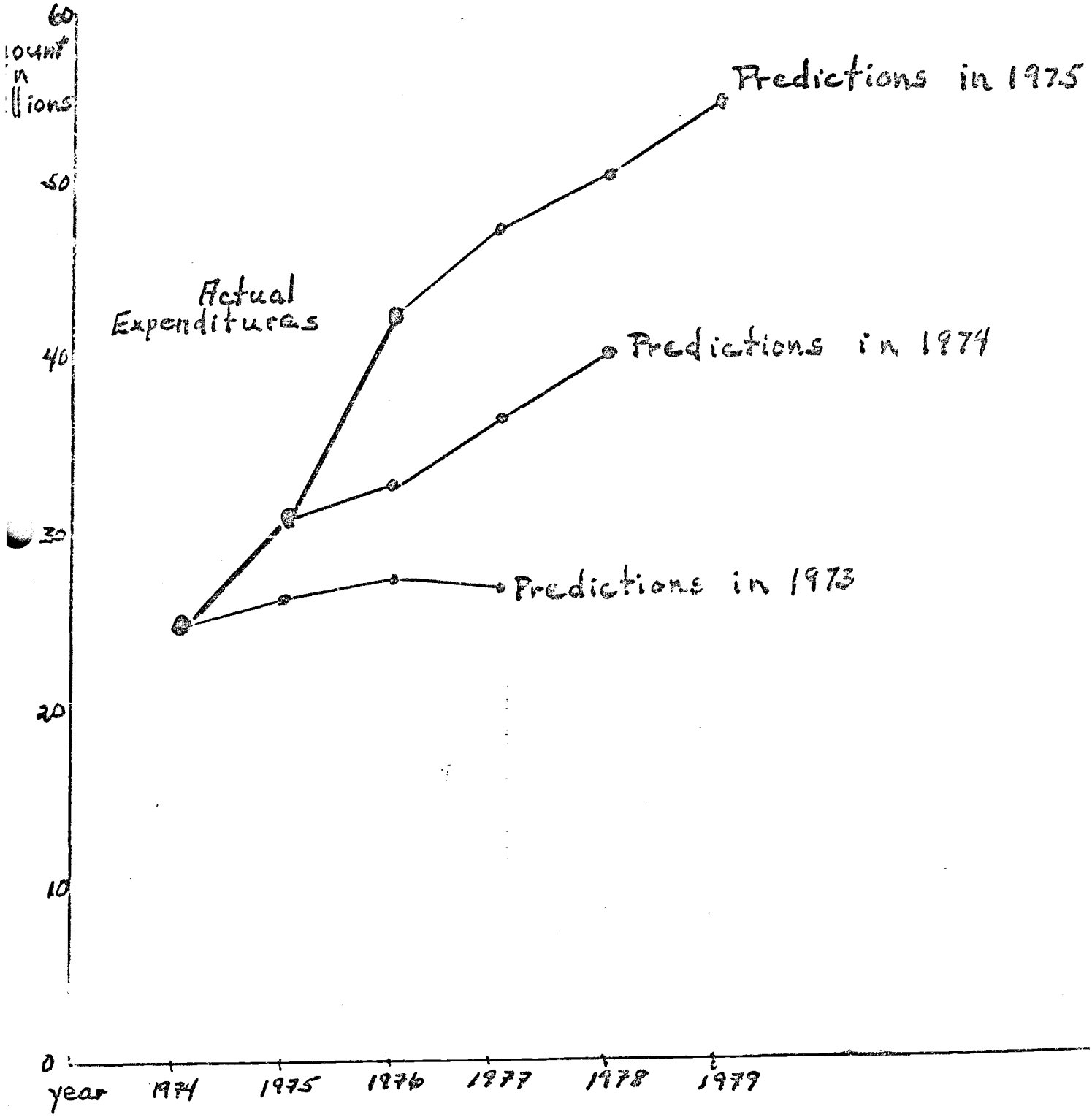
CONCENTRIC (ORBITAL) PLAN OF ORGANIZATION



FUNCTIONAL ORGANIZATION



Actual Expenditures vs Predictions of 6 Established International Agricultural Research Centres



Source: (1) 1973 C.G. Report Annex VIII
(2) 1974 Integrative Report
(3) 1975 Integrative Report